Providing probabilistic forecasts for wind speed using ensemble MOS

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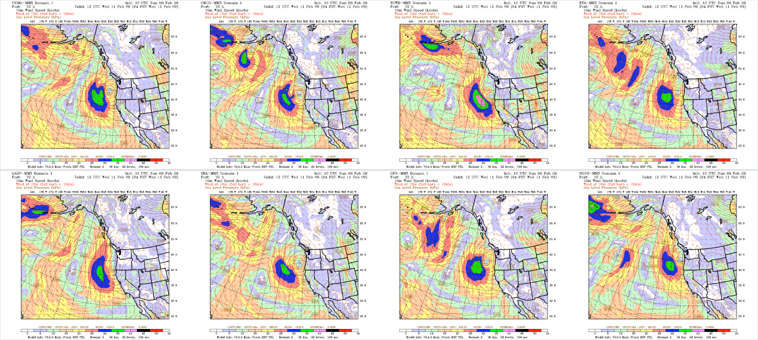
Joint work with Tilmann Gneiting

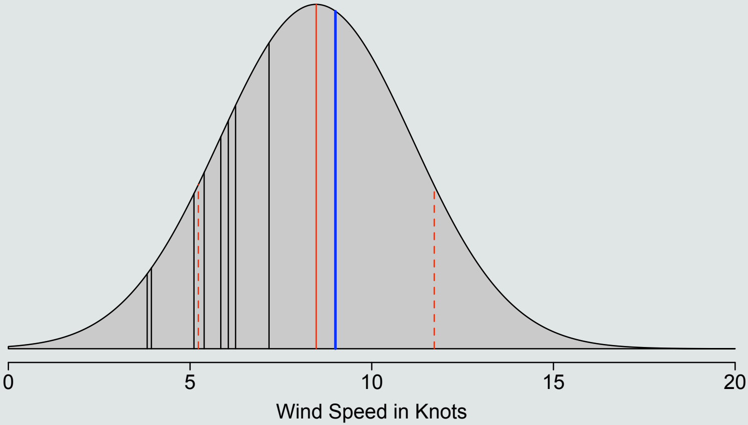
UWME

The UW ensemble system, UWME, (Eckel and Mass, 2005) has eight members using different initial conditions from meteorological centers around the world.



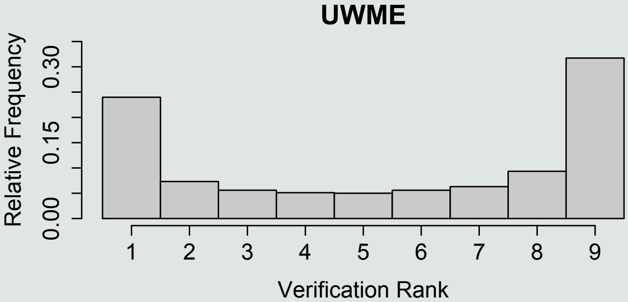
An example of 72 hour ahead forecast of surface wind speed.

Probabilistic Forecast for Wind Speed



Post-processing of Ensembles

Current ensemble systems are often uncalibrated and the NWP models have a built-in systematic bias for some parameters.



If the ensemble were a random sample from the true predictive distribution for the weather quantity, the rank of the observation when pooled with the ensemble would be uniform on $1, \dots, 9$.

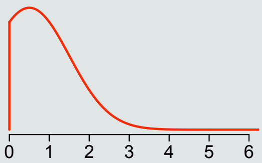
Ensemble Model Output Statistics (EMOS)

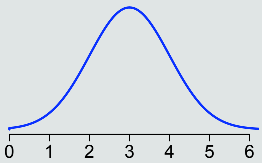
Let $X_1, \ldots, X_k$ denote an ensemble of individually distinguishable forecasts for a non-negative weather quantity Y.

We propose to use a truncated normal predictive distribution

$$N^0(a + b_1 X_1 + \cdots + b_k X_k, c + dS^2),$$

where S^2 is the ensemble variance.





Scoring Rules

A well known scoring rule for deterministic style forecasts is the mean absolute error (MAE)

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |y_i - \mu_i|,$$

where μ_i denotes a deterministic-style forecast and y_i is the verification.

The continuous ranked probability score (CRPS) is appealing as it addresses calibration as well as sharpness. If F is the cdf of the forecast distribution and y is the verification, the CRPS score is given by

$$CRPS(F, y) = \int_{-\infty}^{+\infty} [F(x) - \mathbb{1}\{x \geq y\}]^2 dx.$$

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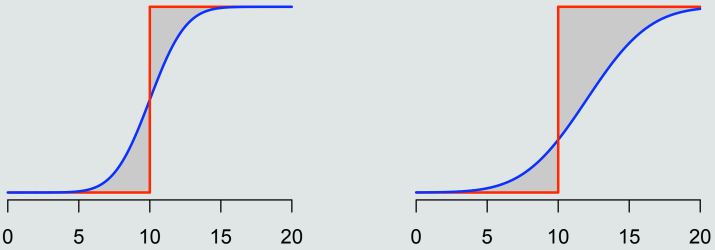
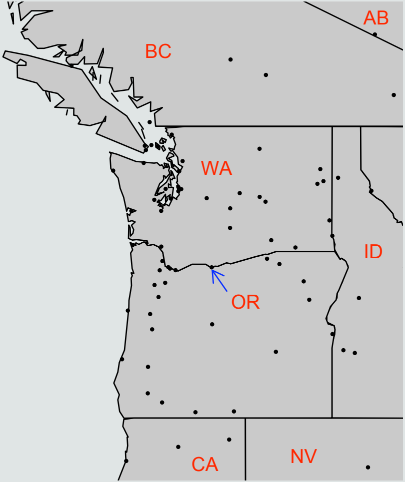


To estimate our parameters, we minimize this function using the verification data from n days prior to the issuing date.

Application Example



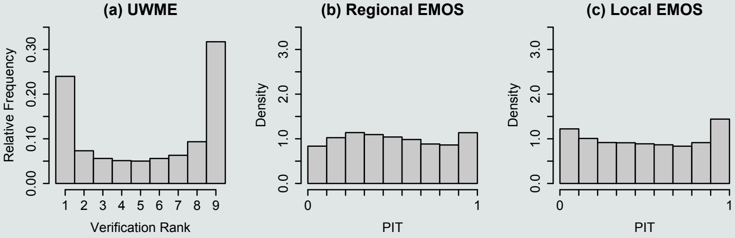
- Data: forecasts for 48 hour ahead maximum wind speed and observations from 73 SAO stations in the Pacific Northwest.
- We want to create 48 hour ahead forecasts for maximum wind speed at all the stations for all available days in 2008.

Application Example

We investigate two versions of the method:

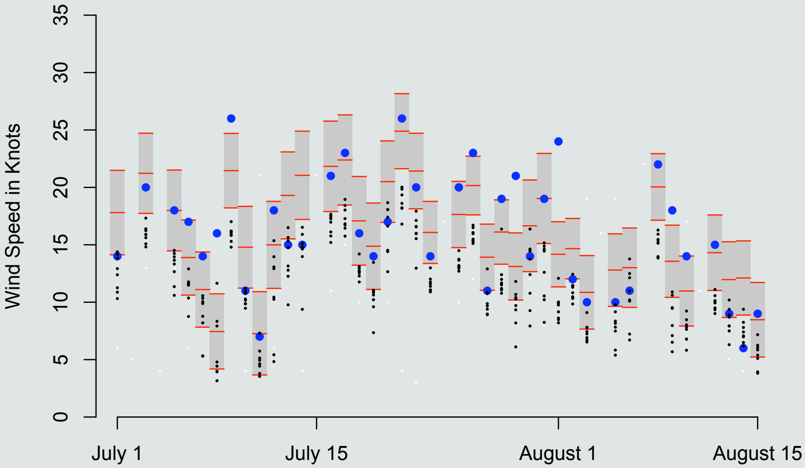
- Regional EMOS: on a given day, one set of parameter estimates is obtained for all the stations simultaneously. Here, $n = 20$.
- Local EMOS: on a given day, a separate set of parameter estimates is obtained for each station. Here, $n = 40$.

Predictive Performance



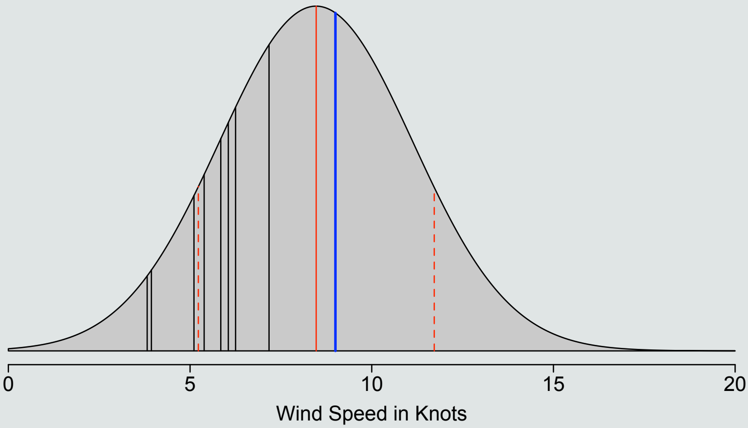
Forecast	CRPS	MAE	Coverage	Width
UWME	2.47	3.15	44.3	4.7
Regional EMOS	2.16	3.00	78.1	8.9
Regional Persistence	2.85	4.01	80.8	11.7
Regional Climatology	2.79	3.92	83.1	12.2
Local EMOS	1.89	2.61	70.4	6.7
Local Persistence	2.53	3.60	76.7	10.1
Local Climatology	2.45	3.50	79.6	10.0

Predictive Performance at The Dalles, Oregon



Predictive Performance at The Dalles, Oregon

The predictive distribution for August 15, 2008.



Conclusions

- Ensembles of wind speed forecasts can be biased and uncalibrated. This may be improved substantially using EMOS to post-process the ensemble.
- Additionally, the EMOS method will provide a probabilistic forecast for the wind speed.
- Based on the probabilistic forecast, a point forecast is obtainable based on any loss function of interest.